Target Areas for Enhanced Research Funding and Milestones Toward an Improved National Ranking

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NEW JERSEY
COMMISSION ON HIGHER EDUCATION

TARGET AREAS FOR ENHANCED RESEARCH FUNDING
AND
MILESTONES TOWARD AN IMPROVED NATIONAL RANKING

INTRODUCTION

The quality of institutional research, particularly at New Jersey's research universities, is critical to the competitiveness of both the institutions and the state. Strategic efforts to enhance the quality of research, expand the boundaries of knowledge, and increase the amount of research funding for colleges and universities in the state are essential for New Jersey to maintain a competitive economy and improve quality of life. *A Blueprint for Excellence: New Jersey's Long-Range Plan for Higher Education* recognizes the importance of increasing research funding from all sources and specifically calls for an increased ranking in New Jersey's aggregate share of federal research funding from 21st to 15th.

The New Jersey Commission on Higher Education facilitated the preparation of a broad statewide strategy to organize this undertaking, working primarily with the presidents and representatives of the four research universities in New Jersey and in consultation with the Executive Director of the Commission on Science and Technology. Presidents of all other colleges and universities also provided feedback and assistance in developing this report, which targets specific research areas that have the greatest potential for additional funding and also sets milestones to assess progress over time. In order to accomplish the ambitious goals set forth, bold and significant initiatives will be necessary related to (1) public policy; (2) collaboration among universities, government, and the private sector; and (3) state investment.

PROPOSED TARGETS AND MILESTONES

Several states, such as North Carolina, Michigan, Georgia, and California, acknowledged their universities as instruments of economic growth and significantly invested in them to increase competitiveness and federal and private sector research funding. Given the success of such efforts, many other states are now aggressively seeking to enhance their universities and increase their share of federal and other research dollars. As a result, there will be very aggressive competition for a limited amount of funds.

New Jersey colleges and universities ranked 21st in the aggregate share of federal research dollars in 2002, the most recent year for which data are available. The state that ranked 15th in 2002 expended $448 million on federally funded R&D, which is $133 million more than that expended by New Jersey institutions. In order to close the gap between New Jersey and the state currently ranked 15th, it will be necessary for New Jersey institutions to consistently, over time, increase their percentage share of the total federal research dollars available for higher education.

Currently, the 15th ranked state receives 2.1 percent of federal dollars available, and New Jersey receives 1.4 percent. To grow the state's percentage share of available dollars, New Jersey should annually increase its federal research dollars at a percentage that exceeds, to the greatest extent possible, the annual federal increase in funding available for that year. As a milestone, New Jersey should seek to increase its share of available federal dollars by one-tenth of a percent each year and thereby increase by a full percent over 10 years, which would exceed the current share of federal funds received by the state ranked 15th. Regular assessment of the state's percentage share of federal dollars available will be necessary to track progress; it may be necessary to revise remaining milestones accordingly based on New Jersey's gain relative to other states. It will also be important to strive for and track increases in nonfederal research support for higher education, which leverages additional federal dollars and also improves economic competitiveness.

The significant magnitude of increases necessary between now and 2012 will require major changes in performance that will not be accomplished merely through incremental growth of existing R&D programs. High-profile, large-scale collaborative efforts among state government, the universities, and the private sector will be necessary to determine how and where to make significant investments in university-based research in order to leverage additional dollars from the federal government, as well as other sources. These large-scale efforts lend themselves to the development of research infrastructure, e.g., facilities and staff, that cannot be assembled through the single-faculty-investigator model of more traditional university-based research. It will be important to build on existing strengths, develop a critical mass of intelligence and talent, weave in threads of industry, and develop systemic, multi-institutional research capacity. While a broad range of research will continue in various fields at colleges and universities across the state, and increases in all areas will advance knowledge and assist in achieving the goal of additional research support, it is important to focus the state's major R&D resources on a few target areas with the greatest potential to increase federal and other funding at the magnitude desired.

Five broad areas of research are recommended as targets that represent particularly strong opportunities for increased funding for New Jersey. Each of the areas is important to the state, has broad industry strength, is likely to offer significant increases in overall funds available, and holds great potential for partnerships within the state. The five research areas are: Stem Cell Research, Biomedically Related Nanoscience, Homeland Security, Advanced Imaging Technology, and Genomics/Bioinformatics. These five targeted research areas are summarized on the following pages, with an explanation about opportunity, research focus, and current assets in each area. While changing circumstances at the state and federal level may result in a change in the specific target areas or a limitation of targets over time, these five areas provide a strong initial focus with potential to greatly increase the amount of federal and other research dollars for higher education in New Jersey.

STEM CELL RESEARCH

Opportunity: Stem cell research represents one of the most exciting and promising new fields of modern biomedical research. Stem cells offer direct therapeutic potential for a wide variety of major intractable diseases including Alzheimer's, Parkinson's, cancer, diabetes, cardiovascular, and neuromuscular disorders and injuries. Already, relatively crude forms of stem cell therapy (e.g., bone marrow transplantation) are accepted modalities in the treatment of a number of hematological diseases and cancer, providing proof-of-principle examples of the potential for wider and more effective application.

Stem cell research also contributes directly to basic studies of molecular and cell biology, developmental biology and genetics, physiology, and neuroscience, which are all areas of strength in the state's research universities that will be significantly enhanced with increasing emphasis on stem cell research. Although there are political issues and federal limitations surrounding the study and use of stem cell therapy, they restrict only federal funding of development or experimentation with new human embryonic stem cell lines. Privately funded research and work with existing (approved) lines, adult stem cells, and stem cells from model animals are not restricted at all. And there is a strong possibility that the federal limitations will be relieved in the future. In any event, substantial funding opportunities exist at the federal, state, and local levels, from many private donors, a growing industry related to the technology, mature pharmaceutical and biotechnology companies, and a large number of patient advocacy groups.

New Jersey has very important advantages in this regard. In addition to courageous and forward-looking state commitment to the establishment of a major stem cell research center at Rutgers/UMDNJ in New Brunswick, there is a concentration of pharmaceutical and biotech corporations and current internationally recognized stem cell research programs, and the state is the home to several recognized and very effective public spokespersons and supporters for this research, all of which enhance funding prospects. Because of widespread local political support, New Jersey's stem cell center also can serve as a center for public discourse and research in related areas of medical ethics, economics, health care delivery, and health care disparities in relation to this emerging new technology, and attract federal and other funding in this area. A concentration of effort in the field of stem cell biology will result in not only enhanced state research funding but also the location, or relocation, to the state of developed or start-up companies seeking to exploit this technology. The concentration of effort would result in far greater competitiveness for large grants and research contracts and provide economic benefit.

Research Focus: Stem cell research in New Jersey will focus in neuroscience and neurological disease and injury, an existing strength, and also in metabolic diseases, cancer, child development, and cardiovascular disease – all areas of clinical strength and interest. New Jersey's work in this field also will intersect closely with existing programs in engineering, biomaterials, surface chemistry and materials science, novel devices, and nanotechnology, both in universities and in the local industrial base. Education and specialized training programs also will provide a stream of capable personnel in this highly technical discipline, helping to ensure continued development and investment.

Current Assets:
Stem Cell Research: major, recognized programs at Rutgers and UMDNJ and substantial individual-investigator funding in Princeton's Molecular Biology department; national award winning adult stem cell research at NJIT; strong clinical programs in near-term areas of application; strong cooperation among involved research universities; collaboration with Coriell Institute (Rowan University)

Biomaterials: existing productive collaboration among Rutgers, UMDNJ, and NJIT scientists

Local Industrial Base: Johnson & Johnson, corollary research centers - CABM, EOHSI, DIMACS and BioMAPS, Pharmacy, CINJ, Cardiovascular Institute, Child Health Institute

Genetics and Developmental Biology: Princeton, UMDNJ, and Rutgers

Engineering and Nanotechnology: Rutgers, NJIT, and Princeton

BIOMEDICALLY RELATED NANOSCIENCE

Opportunity: The U.S. government is committed to spending over a billion dollars annually on nanotechnology research. The President's 2004 budget provides $847 million for the National Nanotechnology Initiative (NNI), a 9.5 percent increase over 2003. Five federal agencies are designated as NNI sponsors: NSF, DOE, NASA, NIST, and EPA. The Nanotechnology Research and Development Act of 2003 authorizes these NNI agencies to spend $2.36 billion over the next three years on nanotechnology research and development. Furthermore, the 21st Century Nanotechnology Research and Development Act authorizes as-yet-unquantified support for nanoscience, nanoengineering, and nanotechnology research through the awarding of grants; the creation of nanotechnology research centers; and the formation of a research program to identify the ethical, legal, environmental, and other societal concerns related to nanotechnology. These legislative mandates do not even begin to describe the magnitude of nanotech-related funding opportunities for universities and research institutions, because "nanotechnology" is a gateway term that encompasses broad areas of interdisciplinary science and technology that are central to the mission of every federal funding agency. The NIH Roadmap, for example, includes an entire suite of programs in molecular science and technology as well as a program specifically dedicated to nanomedicine.

Research Focus: The very breadth and disciplinary diversity of the nanotechnology field introduces the need to define a clearly focused mission and identity that stands out among others. New York and Pennsylvania both have several years head start in mounting major nanotechnology initiatives fueled by hundreds of millions of dollars of state investment – and they are not clearly the leaders. New Jersey can penetrate with a focus that is unique, and the connection to the needs of the full cross-section of the state's healthcare industry is too important to be overlooked.

New Jersey has a unique opportunity in the nanotechnology field to capitalize on its competitive strengths in the very areas of research, development, engineering, IT, manufacturing, and regulatory compliance that shaped the state's world-class biopharmaceutical franchise. Here we introduce the term "Biomedically Related Nanoscience" to describe nanotechnology-related pursuits directed to either (i) solving biomedical problems or (ii) applying biological principles to the solution of environmental, industrial, and/or commercial problems.

New Jersey's Biomedically Related Nanoscience effort will enable resolution of molecular signatures of health and disease; application-directed nanofabrication of devices of decreasing size (top-down); biomimetic assembly of molecular constructs of increasing complexity (bottom-up); and broad, transdisciplinary use of biological principles in designing efficient and effective industrial processes and systems. Commercial applications include not only healthcare and the broader life sciences marketplace, but also major industrial, environmental, public health and welfare problems whose solutions may be informed by the behavior of complex molecular ecosystems that make up biological cells, tissues, organs, and organisms. Such an endeavor will embrace all of the talents in our universities, as it truly requires equal parts of molecular and cellular biology, clinical medicine, physical science, informatics and information technology, and engineering to produce functional structures that mimic, repair, replace, or improve biological function.

Current Assets: Among the state's universities, military labs, federal research facilities, and the private sector, New Jersey is rich in resources that fueled the growth of the state's pharmaceutical franchise and are being reinvested in new technology discovery, translation, and commercialization. Core competencies within New Jersey universities and research institutes include:

NJIT: Biomedical engineering; molecular, cellular and tissue engineering; advanced materials, engineered nanoparticulates and nanofibers; nanoscale separation technologies; microfabrication and nanoscale fluidics; biomedical sensors, transducers and actuators; and nanoscale production, processing and monitoring technologies

PHRI: Genomics, proteomics and microarray technology; Molecular Beacons for real-time detection of molecular and cellular events; molecular biology and molecular genetics, including molecular mechanisms of infectious diseases and cancers; public health and safety

Princeton University: Integrated photonic devices, sensors, organic/flexible devices; optoelectronic technologies for development of inexpensive, lightweight, low-energy displays, large-area electronics, lighting systems, solar cells, and transistor circuits; nanoimprint lithography for cost-effective, high-resolution manufacture of devices such as optical displays, data storage, MEMS and semiconductor devices; DNA processing and analysis devices; organic/inorganic interfaces; self-assembly and surface patterning

Rowan University: Three-dimensional bone templates; magnetic nanostructures and sensors; TIRFM studies of DNA repair; nanoscale sensing/mapping of biological macromolecules; nanoscale fabrication techniques

Rutgers: Nanostructured materials and nanoscale devices; inorganic/organic nanotechnology; surface modification, nanophotonics, nanoelectronics and nanosensors; bio-nano-robotic systems; nanofabrication and nanolithography; nanoscale chemistry (catalysis); critical enabling devices;

multimodal sensors; smart packaging using nano-porous alumina substrates; nano-biopharmaceuticals

Seton Hall University: Laser-based polymeric nano-composite coatings that prevent biofouling; nanoscale electronic devices, surface modifications, and sensors; micro-scale chemical sampling and analysis; fluorescence and real-time PCR technology; confocal microscopy system; functional genomic/proteomic microarray facility

Stevens Institute of Technology: Microchemical systems, miniature power generation and safe on-demand production of critical chemicals; ultra-high heat and mass transfer; micro-volume control for chemical reactors; just-in-time production (reducing transport of hazardous materials); multifunctional surface design via thin films; photonic crystal fibers with functionalized surfaces and polymer-based functionalization provides three orders of magnitude in improvement for detection of chemical and biological agents, even at low concentrations; micro-kinetic test beds and rate mechanisms for micro-reactor design; hierarchical models of integration from systems point of view; drugs from bugs using nanomaterials for delivery

UMDNJ: Bioinformatics (including genomics, proteomics, and microarray); cellular and molecular biology; signal transduction; molecular and nanoscale modeling; rational drug and vaccine design; protein structure/function analysis; structure, design, and molecular compatibility of biomaterials; medical imaging; medical devices; drug delivery; and cardiovascular and neurobiology research

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HOMELAND SECURITY

Opportunity: According to the OMB Budget Statement for the Department of Homeland Security:

> At $803 million, the 2004 Budget for the Department of Homeland Security's (DHS) science and technology activities represents almost an eight-fold increase in funding over the 2002 Budget. DHS will develop and implement a long-term research and development program that includes investment in revolutionary capabilities with high payoff potential. DHS will harness the expertise, energy, and ingenuity of the private sector, academia, and government labs to develop and produce advanced technologies, systems, and procedures needed for homeland security. In 2004, $350 million in new funding is requested for vigorous research, development, test, and evaluation capabilities. In addition, funds will support the development of standards for homeland security equipment that will be used by the state and local first responder community for dealing with current and emerging threats. Finally, research and development activities will be funded to enhance the broad spectrum of missions within the Department, such as improving capabilities for inspecting cargo and processing people at our borders, and dealing with natural or man-made disasters.

In addition to overt DHS funding, other agencies will fund research and development activities that support the underlying technologies for improved homeland security. As a new entity, DHS

R&D funding is not already precommitted to a well-established base of universities. The practical, application, and standards focus of New Jersey's Homeland Security Technology Systems Center opens the door to immediate funding for technology evaluation and standards setting, while creating the framework to understand the research issues from the ground up.

Research Focus: The application areas for homeland security include:

- Emergency Preparedness and Response
- Defending against Catastrophic Threats
- Protecting Critical Infrastructure and Key Assets
- Border and Transportation Security
- Intelligence and Warning
- Domestic Counterterrorism

The technologies for improvement in security across each of these domains tend to be cross-cutting and track the following focus areas established in the New Jersey Commission on Jobs Growth and Economic Development study on academic research.

Information Technologies

- Collaborative Computing and Decision Support Systems
- Data-mining and pattern recognition technologies
- Cyber Security and Intrusion Detection
- Cryptography and Steganography
- Disaster and Response Modeling and Simulation

Telecommunications

- Wireless Communications (high-speed, high-bandwidth, long-range digital communications)
- Communications Interoperability
- Ad-hoc networking
- Remote sensor monitoring
- Asset Tracking Systems

Life Sciences and Healthcare

- Toxin and Infectious Disease Diagnosis and Treatment
- Syndromic Surveillance and Disease propagation modeling
- Mass Casualty Response

Materials

- Protective Materials for Hazardous Environments
- Novel Sensor Materials
- Toxic Chemical, Biological Agent and Fire Suppressant/Containment Materials
- Portable/Renewable Energy Sources

Sensors and Devices

- Chemical Nuclear Biological and Radiological Detection Systems for Air/Water/Land

- Robotic Systems for Inspection and Interdiction
- Biometric Identification Technologies
- Perimeter and Infrastructure Intrusion and Tampering Detection

Current Assets: Among the state's universities, military labs, federal research facilities, and the private sector, New Jersey is rich in resources that span all of these application and platform areas.

Information Technology: DIMACS(RU); Human Computer Interaction (NJIT); Public Health Alert System (NJDHHS & NJIT - HAN/LINCS); Collaborative Computing (Turoff/Hiltz – NJIT); Center for Advanced Information Processing (RU); Lucent Bell Labs; International Intermodal Transportation Center (NJIT); NSA Center for Academic Excellence in Information Assurance (NJIT); Informatics Institute and Clinical Informatics (UMDNJ); Cyber Security and Intrusion Detection (Fairleigh Dickinson University); disaster and response modeling and simulation (Rowan University); collaborative decision support systems (Rowan University); GIS and Remote Sensing Laboratories (Montclair State University); Center for Scientific and Computational Visualization (Montclair State University); Center for Rapid Response Data Base Systems (Monmouth University); Trusted Information Assurance and Cyber Security – NSA Center for Academic Excellence in Information Assurance; privacy preserving data mining; mitigation strategies for denial service attacks in wireless networks; cryptographic protocols; biometric authentication; steganography (Stevens Institute of Technology)

Telecommunications: WINLAB (RU); Center for Communications and Signal Processing (NJIT); New Jersey Center for Wireless and Internet Security (NJIT co-Princeton and Stevens); Verizon; Lucent Bell Labs; NJN; Sarnoff Labs; Single Click Communication (SCC) System (Fairleigh Dickinson University); Robotic Rover Prototype (Fairleigh Dickinson University); asset tracking (Rowan University; WiNSeC-Wireless Network Security Center (Stevens Institute of Technology); interoperability, secure, on-demand broadband wireless networking; multi-network radio ad hoc networking; energy efficient routing; cognitive radios; designed and implemented secure broadband wireless interconnection networks for first responder EOCs (Stevens Institute of Technology)

Life Sciences and Healthcare: New Jersey Center for Biodefense (UMDNJ); New Jersey Center for Public Health Preparedness (UMDNJ); Public Health Research Institute (Newark); Center for Advanced Biotechnology & Medicine (RU and UMDNJ); Passaic River Institute (Montclair State University); studies of post-traumatic stress disorder and Gulf War syndrome (Seton Hall University); Opiate HIV-1 interaction on the central nervous system (Seton Hall University)

Materials: Polymer Processing Institute (NJIT); PRISM (Princeton); New Jersey Center for Biomaterials (RU co-UMDNJ and NJIT); Center for Membrane Technology (NJIT); Seton Hall University X-ray Characterization Facility; pulsed-laser deposition; strong research in materials synthesis and characterization (Seton Hall University)

Sensors and Devices: Microfabrication Center (NJIT); Terahertz Imaging Lab (NJIT); New Jersey Center for Microflow Control (NJIT); York Center for Environmental Engineering and Science (NJIT); Center for Advanced Food Technology (RU); Princeton Plasma Physics Lab; New Jersey Nanotechnology Consortium (Bell Labs); Sarnoff; Seton Hall University X-ray Characterization Facility; pulsed-laser deposition (Seton Hall University); quantum-cascade lasers

in the mid-infrared for low-level remote detection of chemical agents (Seton Hall University); advanced separation science capability: GC, GC/MS, HPLC (Seton Hall University); optical sensing devices for perimeter protection; acoustic sensors for swimmer detection – port security (Stevens Institute of Technology)

ADVANCED IMAGING TECHNOLOGY

Opportunity: Imaging has applications to medicine and biology, homeland security, engineering and materials science, nanotechnology, computer science, and many other crucial fields of science and technology. Important advances are being made in imaging hardware and software, as well as in information processing and distribution. The NIH has made a commitment to enhanced support for biomedical applications of imaging through its new director, Elias Zerhouni, himself a radiologist, because of the potential for providing immediate improvement in disease detection and diagnosis and patient care. Advanced imaging capabilities will make the state's healthcare institutions more competitive for large clinical grants and contracts in treatment and prevention. The Department of Homeland Security has a major interest in accurate, high-speed technologies for identification of individuals at portals of entry into the nation, and surveillance of transportation routes for detection of movement of hazardous agents or weapons, areas of current research in New Jersey's research centers, among other initiatives. Related areas such as structural biology, rational drug design, cell biology, and physiology, also benefit greatly from advanced imaging and image processing capabilities, and would add to the competitiveness of these New Jersey strengths in their attempts to enhance funding through large-scale, multidisciplinary and multi-institutional grants and contracts.

Research Focus: Areas of focus for New Jersey universities include biology and medicine, both clinical and basic research; nanotechnology, engineering, and image processing, including both hardware and software development; homeland security; telecommunications; and transportation. A special emphasis will be placed on the intersection of image processing and data distribution and clinical research in biomedicine, combining many strengths of the state's universities and industrial base. An additional niche for the state's efforts in this area will be the application of advanced imaging techniques to stem cell research, a field with considerable potential.

Current Assets:
Biological Imaging: Rutgers – Biomedical Engineering and Computer Science, structural biology, DIMACS and BioMAPS; UMDNJ – Informatics Institute: Center for Biomedical Imaging and Informatics, 500 and 600 MHz NMR, standard MRI and PET (position emission tomography) machines, a high resolution 3T MRI, and a PET/CT scanner; NJIT – a field emission scanning electron microscope, an Energy Dispersive X-Ray Spectroscope, an energy transmission electron microscope, an electron energy loss spectroscope, novel ultra-sonic imaging systems fabrication, and Terahertz imaging technology; Rowan University – Imaging and Nondestructive Evaluation Laboratory; Montclair State University – Scanning and Transmission Electron Microscopes, EDX; Seton Hall University – Scanning Tunneling and Atomic Force Microscope Facilities; 500 MHz NMR; Ramapo College of New Jersey – research on dose reduction in

mammography and MRI imaging of osteoporosis and research on noninvasive spectral measurements of blood to determine glucose and sodium concentrations

Information Processing: Rutgers – CAIP, mathematics and computer science, electrical and computer engineering; NJIT – multi-spectral image analysis, advanced pattern recognition, organ modeling, and virtual reconstruction; Montclair State University – GIS and Remote Sensing Laboratories; Center for Scientific and Computational Visualization; Seton Hall University – Seton Hall Computational Center; Stevens Institute of Technology – detection of anomalies in a crowd; high resolution for IR imaging (12 micron)

GENOMICS/BIOINFORMATICS

Opportunity: Biology is at a crossroads in its history. The National Center for Biotechnology Information (NCBI) currently lists complete genetic blueprints for over a thousand viruses, hundreds of bacteria, and about 15 higher organisms. Many more sequence projects are near completion. The mapping of the human genome sequence, an enormous scientific undertaking and achievement, was completed in 2003. Improvements in technology in the area of structural biology have led to a virtual explosion in the number of biological molecules for which we have the three-dimensional structure at angstrom-level resolution.

This avalanche of new information in genomics and structural biology poses a fundamentally new challenge for biologists who are studying the principles that drive the *integration* of information in complex biological systems. There is a need to deal with the explosion of information based on the genomic sequences of the human and all major experimental organisms. With complete genetic blueprints that will give us the identities of all biological molecules almost in hand, there is now an exciting opportunity to study how the component parts are assembled into the whole. The problem is a fundamental one, and its solution requires, in addition to existing paradigms of molecular biology, new sets of analytical tools that are likely to come from outside the discipline of biology. Biologists must seek the assistance of researchers trained in physics, chemistry, computer science, mathematics, engineering, and other fields that routinely manipulate large datasets, manage complexity, and address problems of integration, to collaborate on these solutions.

The importance of research in genomics and bioinformatics aimed at understanding the molecular basis of disease to issues of human health and well-being is obvious. Such maladies as Alzheimer's disease, Parkinson's disease, cancer, Pendred syndrome (deafness), tumor suppression, neurological disorders, and developmental disorders are the target of ongoing research efforts in this area. In 1989 a new National Human Genome Research Institute (NHGRI) was established within the National Institutes of Health specifically to focus upon understanding the structure and function of the human genome and its role in health and disease. NHGRI supports the development of resources and technology that will accelerate genome research and its application to human health. Its funding level has increased significantly during its short existence, with a budget of $479 million in fiscal 2004. Congress has routinely treated NIH favorably in terms of appropriations, in recognition of the national priority that behavioral and

biomedical research enjoys by virtue of its relevance to and impact on the long-term health of the human race. New Jersey's research institutions, with their breadth and depth of expertise in the varied disciplines that collectively contribute to the fields of genomics and informatics, are well-positioned to take advantage of the anticipated continuing emphasis in terms of funding priorities, both via the federal government and private sponsors, for this challenging and expanding field of scientific study.

Research Focus: The applications for genomics/bioinformatics are widespread and cross-cutting, in terms of biomedical and behavioral implications. Broadly speaking, the following represent specific areas of research opportunity and potential focus:

- Genomics
- Biophysics
- Computational neurobiology
- Systems biology
- Population biology
- Quantitative genetics
- Molecular evolution
- Computational biology
- Microbial interactions

Current Assets:

Princeton: The Lewis Sigler Institute for Integrative Genomics and the Department of Molecular Biology have major research programs focusing in the following areas:

- Developing realistic and quantitative models of biological processes;
- Collecting large-scale data sets comprehensively describing biological processes;
- Devising new and improved methods for computational analysis and display of complex models, structures, and data;
- Providing applied solutions to specific biological questions in the subject areas of
    - spatial patterning during development,
    - intracellular signaling and transcriptional networks, and
    - virus-host interactions.

Rutgers: Protein Data Bank (a worldwide resource for structural biology and genomics); Human Genetics Institute (one of the world's largest repositories of genetically defined cell lines and related resources, and centers for genetic analysis of human disease); BioMAPS; DIMACS; Biostatistics Center; Waksman Institute (plant genomics); Cell Biology and Neuroscience; Cook College Biotechnology Center and Agricultural Experiment Station

UMDNJ: Informatics Institute (conducts research and training in bioinformatics and computational approaches to biological problems using an integrated array of hardware platforms and computer applications for molecular modeling, sequence analysis, drug design, and DNA analyses); Center for Applied Genomics (multi-institutional collaboration with PHRI and NJIT develops DNA and protein chip technology for use in medical and biological research); Center for Human and Molecular Genetics (employs molecular screening technologies to study the occurrence and distribution of genetic disorders in populations); Center for Advanced Proteomic

Research (provides a wide array of sophisticated instrumentation for analyzing the expression and structure of proteins); Center for Advanced Biotechnology and Medicine - jointly operated by UMDNJ and Rutgers (conducts Proteomics research); Center for Biomedical Imaging and Informatics (develops and applies informatics tools for computer-assisted diagnoses, biomedical pattern recognition, cancer tissue microarray)

NJIT: Microarray and microanalytic device technology sustained by Class-10 Microfabrication Center and additional support through access to New Jersey Nanotechnology Center SFRL; Center for Applied Genomics (multi-institutional collaboration with PHRI and NJIT develops DNA and protein chip technology for use in medical and biological research); computational biology program in mathematical sciences and Sloan Foundation supported cross-disciplinary Bio-Informatics program and research teams; Directed Molecular Engineering program; biochemical and biochemical engineering researchers

Montclair State University: Data mining and knowledge discovery; data cleaning; bioinformatics laboratories with access to significant databases: genomic (Panzea), genome express system (GEDB), and cyanophage knowledge base (Cyanogroup); DNA sequence and microarray data analysis

Seton Hall University: Biophysics research: DNA complex structure, function, and mechanisms; Biophysics research: proteins and gene expression; strong research in neuroscience, including studies of the blood-brain barrier, neuroinflammation, and neurotransmitter receptor genes; antibody microarray and cDNA microarray protocol and genetic diversity assay development

Ramapo College of NJ: Research on DSEF-1 protein in mammalian polyadenation, and GRS in the regulation of RNA processing events

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CONCLUSION AND NEXT STEPS

The state, its research universities, and other colleges and universities where appropriate to their mission have a significant challenge before them to increase New Jersey's ranking in aggregate share of federal research dollars for higher education from 21st (in 2002) to 15th by 2012. The magnitude of this increase will require more than incremental growth of existing R&D programs at institutions. It will require a significant investment of state and private sector resources focused on a few target areas that offer the greatest potential for increased federal funding, commercial development, and enhancement of knowledge. Five target areas are recommended: Stem Cell Research, Biomedically Related Nanoscience, Homeland Security, Advanced Imaging Technology, and Genomics/Bioinformatics.

Changing circumstances at the state and federal level may result in a change in the specific target areas or a limitation of targets over time. But the five areas identified provide a strong initial focus with potential to greatly increase the amount of federal and other research dollars for higher

education and also increase New Jersey's role as a national leader in research and economic development. Adjustments in the milestones and goal for federal funding also may be necessary over time as circumstances evolve.

Research universities in New Jersey have increased their federal research dollars greatly over the past several years. But growth at institutions in states with higher and similar rankings has increased as well. It will be essential for the state and private industry to be active partners to achieve the vital and ambitious goal set out in this report. It will be important also to further engage the Commission on Science and Technology (CST) as a partner in building increased competitiveness in the target areas. In addition to the need for significant state and private sector investments, regular (but more modest) support from the CST for early-stage research can greatly enhance the prospects for successfully obtaining federal and other research funding.

State efforts are already underway to support stem cell research; homeland security research is another area in which higher education is working closely with state government. And the research universities have already initiated discussions about how to enhance successful existing research partnerships and to break down barriers that will allow for the development of new partnerships. The continuation and expansion of such discussions is encouraged in order to develop specific strategies in the target research areas through interinstitutional and private industry partnerships and consortiums and targeted state investments that will provide the strongest possible advantage. The Presidents' Council's newly established Research Committee may provide a venue for expanded discussions.

At the same time, other ongoing efforts at institutions and organizations, such as the Commission on Science and Technology, the Biotechnology Council of New Jersey, and the New Jersey Technology Council, should be continued and where possible, coordinated with institutional efforts to achieve the shared goal of increasing federal and other research dollars for New Jersey universities. The recent report of the Commission on Jobs Growth and Economic Development also provides valuable insights and recommendations to inform this work.

The Commission on Higher Education urges colleges and universities, the state, and the private sector to work collaboratively to develop a bold and momentous plan to increase federal and other research funding in the target areas and thereby enhance the economy and quality of life in New Jersey and beyond. The Commission offers ongoing support through assistance in coordination, facilitation, and tactical planning to achieve this critical goal.